Development of Integrated Assessment Framework for Lean Practices in Construction Industry

Short Synopsis

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CERTIFICATE

I hereby declare that the short synopsis "Development of Integrated assessment framework for Lean Practices in Construction Industry" being submitted in partial fulfilment of the requirement for the degree of Doctor of Philosophy in Civil Engineering under Faculty of Engineering and Technology of Manav Rachna International Institute of Research & Studies, Faridabad during the academic year 2023. It is a bonafide record of original work carried out under the supervision of Dr. Sunita Bansal, Professor, Department of Civil Engineering and Dr. Rajender Kumar, Associate Professor, Department of Mechanical Engineering and has not been submitted in full or part to any other University or Institute for Degree or Diploma. Further, it is certified that short synopsis is plagiarism free and proof has been submitted.

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ABSTRACT

The Civil Engineering construction sector has evolved with automation and advancements of technology but still facing lot of challenges such as poor planning, budgeting, Slow Adaptation to Emerging Technologies which result in delay, time overrun, cost overrun and dissatisfaction to customers. To overcome these challenges, the concept of Lean Construction has been developed to increase customer value in the construction process. Lean Construction is a bottom-up approach based on 'Transformation Flow Value Theory' of production which enhances value for the customer through optimization and/or elimination of flow activities in addition to optimization of conversion activities. The main objective of this research is to investigate the implementation of Lean methods and to deliver a successful project at the end of the construction. This research will investigate the feasibility of implementation of Lean methods to construction projects in India with its social, economic and financial constraints. The data will be collected through structured questionnaire survey, case studies, comparison of Lean building with conventional building. The analysis will be done through quantitative and qualitative mode of research. The research will also include building redevelopment possibilities with Lean Principles and development of a software prototype.

Key words: Construction Management, Lean Construction, Project Management, Project Planning, Project Efficiency

1. INTRODUCTION

Construction industry plays a huge role in the country's growth and development and is the backbone of Indian Economy and GDP. Construction industry has to be efficient in delivering the projects with all the parameters including less wastage of time, safety among workers and so on. Indian Construction industry is facing a lot of challenges and issues in delivering efficient infrastructure projects which results in inefficiency, wastages and so on. Apart from the technical issues at sites there are lots of inherent systemic issues in the process of managing a project like lots of wastes, information flow gaps, coordination issues which result in the inefficiency of delivering projects. To overcome these problems, construction industry has to adopt latest innovative technology which results in growth and development of country. Construction sector has to be developed from both the sides as rural and urban. Lean Construction is one such technique that can be used. It helps to reduce wastage of time, money, resources etc. and maximise the outputs.

Various suggestions have been used to improve productivity in construction. One of the most suggested methods is the use of Lean Construction. Each construction is different on a certain basis whether it may be on the basis of time, resources, model, shape, structure, etc. The concept of Lean was introduced in Japan in the Toyota Production System. The main aim was to reduce the cost, meet the ultimate and deliver in a limited time. Lean management can be used in different areas and its uses such as software development, manufacturing, six sigmas', start-up, healthcare etc. Lean construction aims to boost the sector's innovation, profitability, and production. It is one of the most advanced methods used in the Construction Industry. In India, construction costs are increasing by roughly about 50% over the rate of inflation. As mentioned by Lean Construction Institute (LCI), since the 1960s the productivity and efficiency of the construction sector had decreased. Checks, double checks, and over-specification has been developed as a lack of confidence among clients and contractors. Assembling design teams, contractors, construction workers, and project management teams under single work is difficult. The use of Integrated Project Delivery (IPD) helps to coordinate the entire team as a single group. In each stage of the construction work, certain persons are responsible for each and every work. The final decision clearly specifies the importance of the Last Planner System i.e.in case of the design phase the architect or engineer is the responsible

person while in the case of the construction phase, the contractor is the responsible person. For the improvement of the construction industry construction managers are largely using these Lean Methods. It is very important to move forward by realizing mistakes from the past and correcting them. The role of a construction manager is to adopt the positives from the Lean Method and to find out the solutions to overcome these drawbacks present in the construction sector.

Lean concepts are used in various sectors such as health care, offices, the manufacturing industry, and the education industry. For efficient and proper management of money, and time resources in various small-scale and large-scale industries, bigger and smaller projects require proper management. Lots of difficulties are faced to implement Lean methods in construction sites (Kim & Park, 2006). In India, there are numerous obstacles to implementing the Lean construction approach. Stakeholders such as builders, contractors, and engineers are still against the process of implementing Lean Principles due to a lack of illiteracy and awareness.

The below shown Table.1 depicts the difference between Conventional and Lean Construction. Figure 1 depicts the factors affecting Lean.

Table: 1 Conventional v/s Lean Construction

Conventional Construction	Lean Construction
Ignores the non-value-added activities and only focuses on conversion or transformation activities	Mastery of the complete building process (flows, phases of conversion); take into account value-added activities and non-value-added activities
Insufficient waste-reduction practices	Throughout the project's life cycle, waste must be identified and eliminated (design, construction, and demolition)
Push approach	Pull approach
Organizational structure with a strict hierarchy; the project manager is responsible for scheduling, piloting, and coordinating.	Scheduling, testing, and collaboration with all project stakeholders; An open, concise, and iterative discussion plan

Inadequate visual management	Increased transparency, easier stakeholder communication, and worker safety are all benefits of visual management.
An order-following mechanism underlies the contractual agreements between the project's parties; timeout penalties are offered.	Instead of attempting to identify the cause of a problem and punish the offender, one should look for effective remedies; process optimization in the context of ongoing improvement
Construction site that is not well organised	By using the 5S method, the organisational level of the building site is optimised.
Not having performance indicators	Measurement of the PPC for the purpose of regulating the variance of the construction process (percentage of Promises Completed)

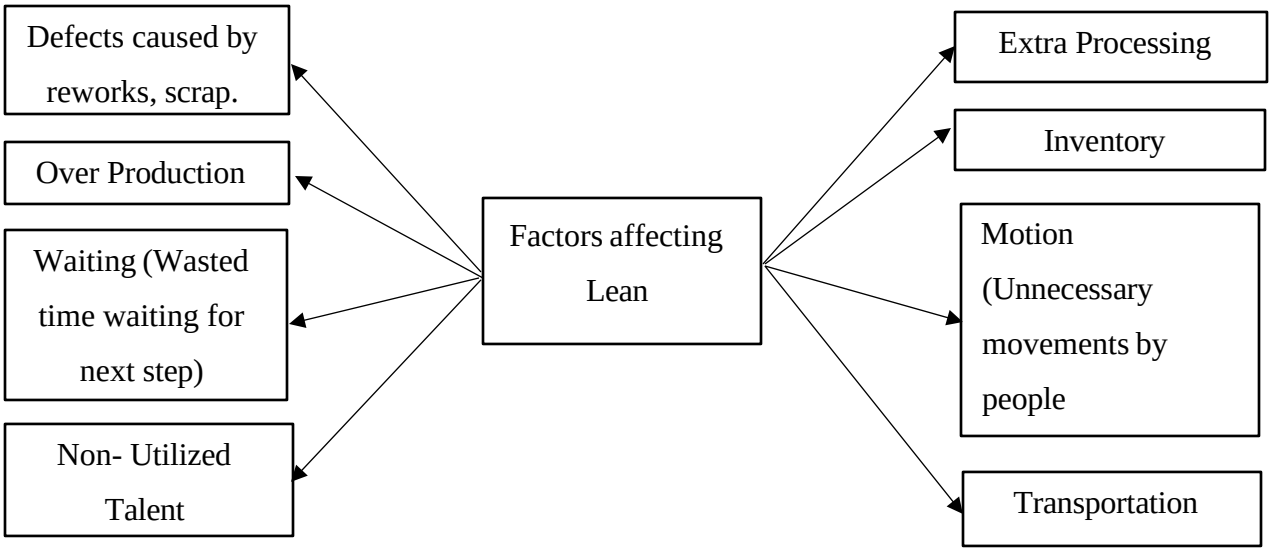

Figure 1: Factors affecting Lean (Source: Sarhan, 2015)

In Construction Industry, one of the most important of Lean tool is the Last Planner System which is created by the Lean Construction Institute. It is an efficient planning system which

includes Master Planning, Daily Work Reporting, Resource Allocation, Expected Time of Completion etc.

1.1. The Lean Principles

Lean Enterprise Institute (LEI) introduced the concept of Lean Principles by James. P. Womack and Daniel. T. Jones (1997). The five Lean Principles: Defining Value, Value Stream Mapping, Creating Flow, Establishing Pull, Continuous Improvement.

1.1.1. Defining Value

In Lean Projects identifying customer needs helps to deliver the customer needed projects. This helps to meet price and other requirements. This fundamental idea should have communicated to all project participants so that they can constantly work on what client needed.

1.1.2. Value Stream Mapping

The next step is to map the value stream after defining the value for your end-user. In order to accomplish this, each step should be described and associated process that goes into creating end product from a raw material. Design, procurement, HR, administration, delivery, and customer support are more areas where you can pinpoint the processes used to make your product.

1.1.3. Creating Flow

After removal of waste from value stream we need to make sure the next processes should flow smoothly to avoid delays, obstacles, interruptions that can slow down the production and risking timeline and budget. To achieve this Value Stream should be done in a specific order. To increase the efficiency collaborating cross functional team's increases productivity.

1.1.4. Establishing Pull

Pull refers to how faster customer can get the result. Pull helps to reduce the time from years to months and months to weeks. This helps to reduce resources, money, costs. The flow established in the previous steps depends on how it exactly works.

1.1.5. Continuous Improvement

This step comes in second place only to the first if the first is the most crucial of the five Lean Principles. It involves working for perfection in all aspects of your corporate culture. You should utilize this step to specifically loop to the initial step. Yes, you must keep doing these actions. Lean project management depends heavily on this continuous improvement, also termed as kaizen in Japanese.

1.2 Importance of Lean Construction.

Lean construction is centred entirely on the idea of reducing waste. This comprises squandered resources, time, and labour with the aim of more effectively creating outputs of greater quality. To increase the work flow process some fundamental concepts, have to be followed. The concept of Lean can be used for companies for their new start-ups. The main aim of the Lean principles is to eliminate the waste and make the process construction process faster (Othman & Abdelrahim, 2019). Wastes in construction industry will not give any value to the projects which will definitely result in increase in production cost, extended completion time and increased use of resources. With the improvement in quality in construction sector, use of Lean Principles leads to make company more competitive, reduce wastes and helps to meet the changes of clients whatever they need to change without affecting the entire work. With the proper management techniques of Lean, the cost, storage space of materials can be reduced to a certain extend resulted in decreasing construction cost Wong & Mohammed Ahmed, (2018). Implementation of Lean is a bigger task, lack of Government support is one of the major challenges faced in the implementation of Lean. To implement Lean, the project will be divided as various sections and each section has a responsible person. In certain cases, unwillingness of division of works to other responsible managers are one of the major challenges in implementing Lean. Lean helps in better team management, better relation with stakeholders, increase in changing priorities in the modern world can be sorted to a greater extend gives more value to customer's perception. Lean methods provide an adequate solution to this problem (Sreedharan & Trehan, 2020). Lean principle can also be applied in the business sector also to obtain a better performance and results. To consider a building as Lean building performance evaluation is required. In production sector also same principles have been used. The main aim is to deliver things with less wastage and maximum efficiency. The results from all the sectors are same which resulted in less wastage, more efficiency, just-in-time delivery etc. Lean construction follows a continuous flow and processes. Flow helps to divide the works equally to workers and resulted in pull planning and just-in-time delivery

1.3 Lean Tools

1.3.1 Bottle Neck Analysis

"Bottle neck analysis" is the systematic approach which helps to identify how many times project got stuck. By identifying and resolving operational and process concerns, bottleneck analysis is also used to address issues that are currently occurring as well as those that may arise in the future. Bottle neck analysis helps to improve time, money value etc.

1.3.2 Just –In –Time (JIT)

With an on-demand approach called "Just in Time" helps the producers to produce manufacturing only after the client has demanded it. This helps to reduce the problems of storage-related damage issues and overstock problems.

1.3.3 Value Stream Mapping

Value Stream Mapping is a Lean Manufacturing method that provides the visualization of all the parts required to offer a product or service. Value Stream Mapping help in the continuous improvement process and is used in varieties of industries.

1.3.4 Overall Equipment Effectiveness

It helps to check whether the planned work and actual work happened on the same date. If the planned work is 6 hours per day and for certain miscellaneous activities, you spent 2 hours. Then the actual work is calculated by worked hours divided to planned working hours.

1.3.5 Plan Do-Check Act

The Deming Cycle is another name for the Plan-Do-Check-Act scientific approach to managing change. Dr. W. Edwards Deming created it in the 1950s. The PDCA cycle consists of four steps: Plan - Identify a procedure or opportunity that needs improvement, Do - Build a quick test, Check - Examine the test's outcomes, Act – Continue based on those findings.

1.3.6 Error Proofing

A common process analysis tool that is founded on the concept of prevention is error proofing, commonly referred to as Poka-yoke. Poka-yoke focuses on ensuring that the proper circumstances are there before any procedure is put in place, according to Business Map, a project management software provider. Defects and human mistakes are less likely to occur as a result of this action.

1.3.7. Last Planner System

Last Planner System is developed by Lean Construction Institute and is one of the important management methods to improve worker accountability and productivity (Anon., 2018). It is one of the most effective tool used in Lean Construction (Ballard & Howell, 1994). Through detailed group planning and scheduling Last Planner System was introduced by the Lean Construction Institute for increased worker productivity and accountability. LPS gives more value to customers. LPS helps to create last planners to each and every work. LPS helps in continuous contact with contractor, subcontractor and workers so that lesser chances of rework, strong communications among responsible persons helps to create better productivity. Work reporting and weekly meetings of LPS helps to create a transparency in construction. The Last Planner System along with Transformation Flow Value (TFV) theory helps in proper management, planning and coordination in construction and provides greater value to customers (Biton & Howell, 2013).

Improper management of materials leads to excessive increase in construction cost which leads to large amount of wastage of money and resources. Hence material management is one of the important factors in construction sector (Karthick *et al*, 2018). With the help of a skilled project manager the problem can be solved to a greater extend. Lean Construction helps to reduce the waste and maintain a material management to create a sustainable construction (Koranda *et al*, 2012). The main two pillars of Lean are continuous improvement and respect to people. In Lean Organisations collaboration among employees, good communication can be achieved through respect among all the employees. Lean Organisations are famous in terms of less mental stress among workers because each and every member's skills, productivity are managed equally which leads to less stress among workers in most of the company's project failures, wastages, delays occur because of the lack of meeting among workers which should be carried out on weekly or daily basis. Through weekly planning, reporting, monitoring, taking feedbacks, correcting the wrong which happened by effective collaboration LPS plays a major role. Lack of acceptance of lean among old aged contractors, engineers play a major role in less productivity. Lacks of acceptance of lean due to certain cultural traditions are one of the major problems faced by the construction industry.

Proper study is required to identify the factors which is not accepting Lean methods and to find out remedies for the better improvement and development. Fig 2 represents a detailed view of last planner system.

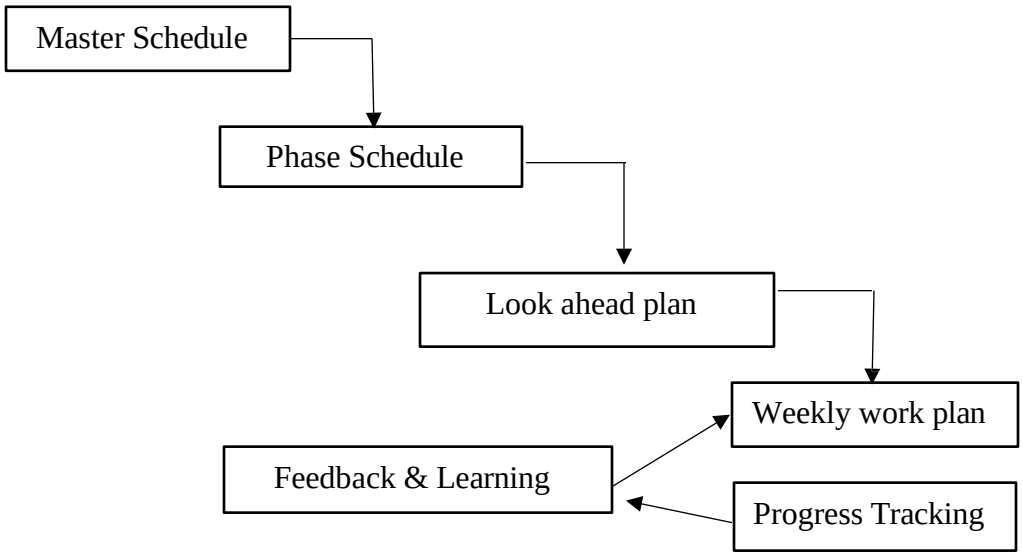

Figure 2: Last Planner System (Ramos, 2017)

Project management helps to manage all the works of construction from the initial stage to the final stage. In the modern world what clients needed is to visualize the things that they are proposing. Everyone chooses for better efficiency, productivity, less cost and to deliver the building as early as possible. Most of the clients did not have a proper idea about the building they need to get constructed. In that case, they will definitely take the support of a design engineer or project planner. The role of the engineer is to make a plan according to the client's point of view.

The management of the project can be done with the help of a project manager. The client may or may not accept this work. If any corrections are needed, then the engineer has to recreate the plan again and work until the customer gets satisfied. During earlier times, software analysis or modelling is not done. In that case when a work is done if the customer needs to make any changes, or if the work is not done according to his point of view nothing can be done. They had to accept that because work is already completed and if they need to make correction, they need to rework on what they had already constructed which results in increase

in time, loss of money, work delay etc. All these problems can be solved with the help of software analysis and software modelling (Li *et al*, 2015).

With the Proper resource allocation in Primavera software, client will be able to identify the expected start date, expected finish date. In most of the cases project will finish within the expected finish date. If any change in decision occurs while doing construction it may affect the whole construction process with increase in cost, time, resources etc. This case will not happen in software method, if any change occurs it can directly be entered to software and can analyse the changes in the Critical Path and make corrections without affecting the total Float. After making changes, rescheduling can be done in software's. Each activity linkage can be changed according to clients or engineers point of view at any time without affecting the entire project. Approximate Cost estimation can be done clearly before the starting of a project and can also be shared with the client. So that identify the allocation and expected cost of the project. Projects can easily visible in a single screen as table view and Gant charts in terms of Primavera. Hence software modelling has a greater acceptancy in the present modern construction industry.

Chart view helps to identify the relationship between work and the responsible person. Corrections can be done with the help of modify option without affecting the whole projects at any time. One main advantages of software system are that multiple projects can be worked at the same time with different folders can save all the projects in the software for future use also. In Primavera budget summary, dates, findings, codes, resources calculations all these are available in a single page which makes it more user friendly to customers and also to planners. These all things cannot be implemented as a single file or in paper in traditional methods.

2. LITERATURE REVIEW

Systematic Literature Review related to Lean Construction had been conducted which helped identify the gaps among the literature and help to frame the objectives of the research. Literature study was mainly focussed on Scopus indexed journals of papers for the past 20 years.

Alarcon & Seguel (2002) conducted a study based on Lean and described the methodology which had been developed by Chilean Construction Company to select employees and their participation in implementing various methods for the improvement of the company.

Formoso & Luis (2002) conducted a study on material waste in building industry and identified that material wastes have been one of the major problems in the construction industry and suggested preventive measures and managerial improvements.

Salem, Solomon, Genaidy, & M (2005) conducted a study in median size construction firms with the application of Lean tools and suggested that Lean resulted in better improvement, productivity and less wastage and recommend suggestions for the future developments.

Senaratne & Wijesiri (2008) conducted a study in Sri Lanka to identify the suitability and acceptability of Lean Methods in construction, collected empirical data and analysed. They identified domestic construction industry is not updated in terms of Lean. Rapid urbanization, climate change, lack of experience, lack of awareness, lack of technologies are the major challenges faced by the construction industry.

Tribelsky & Sacks (2010) carried out a study on problems faced by the construction industry and concluded improper management in construction industry leads to creation of large amount of wastages. Flow graphs are used to identify the faults.

Pepper & Spedding, (2010) conducted a study on Six Sigma to know whether any particular frameworks are used for analysis in Construction sector. Through a thorough review of literature, the study identified that there is lack of framework for implementing Six Sigma and suggested remedies in this paper.

Vinodh et al, (2011) studied about the adoption of Lean Construction Principles in modern construction industry and concluded due to lack of experience and technology in decision making process fuzzy methods in Lean needed to be used.

Bhaskaran, (2012) on his study concluded that application and implementation of Lean manufacturing techniques in Auto Cluster, diagnosing and auditing is carried out and concluded LMC helps to increases productivity and efficiency.

Khoo & Ong, (2013) developed a Structural Equation Modelling(SEM) software which consider all the parameters in construction, and concluded that these software helps in the interpretation of all the parameters which leads to user satisfaction.

Andrade, Pereira, & Del Conte, (2016) applied the concept of Value Stream Mapping in auto-parts company and resulted as a good decision-making process in companies which results in better efficiency, productivity and lesser wastage. Wastes are one of the largest problem faced by the construction industry (Bhatia *et al*, 2016) conducted a study by implementing Lean Principles and Last Planner System to reduce the waste. Waste in construction leads delivers inefficient projects.

Subramani & Rajiv, (2016) applied SPSS in construction industry and identified the improvement in construction efficiency and productivity. Various questionnaire methods were carried out based on labour injuries, shortage of materials, payment delays etc. and done analysis through SPSS. Lean Manufacturing (LM) and Environmental Management techniques had been widely used to reduce waste and increases productivity Sant'Anna *et al*, (2017) in the construction sector to provide a better results and satisfaction to customers.

Ma & Ma, (2017) conducted a study on Integrated Project Delivery (IPD) using various parameters such as contractor, engineer, owner etc. and identified the data from various organisations but unable to meet the requirements of commercial collaborative platforms.

Ramadan, Maimani, & Noche, (2017) proposed a cost tracking system using (RT-MCT) which was connected with the concept of Lean Manufacturing and RFID. This method helps to identify the root causes and should be eliminated to reduce the cost in construction. BIM methods play an alternative to overcome this.

Oguntona *et al*, (2018) carried out an assessment of lean construction practices in the construction industry, carried out questionnaire survey and quantitative data analysis. Lean Principles plays a major role in health care industry and survey was carried out among different healthcare professionals and also analysis is carried out by SPSS (Jain & Ajmera, 2019).

R, (2019) carried out an analysis of lean construction practices in Tamil Nadu Construction Industry carried out questionnaire survey and data collection among various companies in different areas of Tamil Nadu and identified that 52% of companies incorporated for lean implantation.

Rossini, et al., (2019) explained about the application of kaizen in company by high-mix-low-volume production and identified the results as helps in correct time delivery by 75-90% and 10% reduction in production costs. A study on semi- ceramic industry was conducted using lean which helps to reduce the wastage by 32%, time reduction by 36% and labour reduction by 6.85% (Bhamu, Bhadu, & Sangwan, 2020).

Shahin, Chen, Bouzary, & Krishnaiyer, (2020) identified how lean tools and industry 4.0 are linked and its operational implementation in factories.

Braglia, Gallo, & Marrazzini, (2021) MaCD method is used to identify material losses in factories and calculated the loss in terms of quantity and recommend methods to overcome this with Lean.

Monetti, Boffa, Giorgio, & Maffei, (2022) stated that lean factories play a major role in the construction sector. In this lean factory methods had been implemented in school and a survey was conducted among students to know the awareness of lean among students.

2.1 Research Gap

1. Most significant obstacle for the successful completion of project in the lack of data entry at the project level.
2. A large number of studies had already been conducted to identify the barriers and implementation of Lean in construction but use of inappropriate tools of Last Planner System are identified as the main factor.
3. Very few studies had been carried out by Indian Authors regarding Lean Concept.
4. Most of the studies are based on reliability analysis and cluster analysis. Application of Structural Equation Modelling and Multi Criteria Decision Making is limited.
5. In most of the studies the analysis is done through random software's, use of construction management software in analysis is limited.

6. Most of the studies are conducted on proposed or existing building. Lesser number of studies on building redevelopment possibilities using Lean BIM and MCDM.

3. DESCRIPTION OF BROAD AREA

The Lean Technique was initially used in the manufacturing of Toyota Production System. The Lean concept emerged during the earlier twentieth century. The concept of Lean was introduced by Taiichi Ohno and used the concept of Lean as minimizing wastage helps in increasing productivity. The concept was developed after the Second World War. Among various management methods Toyota Production System becomes one of the most advanced methods in the manufacturing sector (Pepper & Spedding, 2010). The principles of Lean can be used in any industry to increase its productivity and maximum output without compromising its quality. Lean is a management method used in the construction industry to reduce the waste throughout the projects entire work. The Lean Construction concept was used in many of the countries like Brazil, Denmark, USA which resulted in better output for their construction sector and contributed to greater economic growth. Lean Construction methods can be adopted in various sectors such as small scale industries, large scale industries, smaller and bigger projects, residential and commercial etc. Lean methods can also be used in Indian construction industry also. Lean Construction and current construction principles seem to be same and both aim to reduce the waste, maximum output, better management of resources, timely work completion etc. But what makes Lean different is that it uses production management principles which results in better management for very quick, complex projects. Construction Industry in India faces a lot of problems in Implementing Lean (P & Jayanthi, 2014).

Lean principle can be used in Modular Construction also resulting in high speed construction work to ensure more safety to workers and reducing the risk, increase construction efficiency and productivity. Proper planning, the risk in storage of materials and handling can be reduced to a certain extent. Principles used in manufacturing cannot be directly used in construction; some sort of changes are required to apply these principles in construction.

Last Planner System is a lean tool which is used to develop a relationship between project control, scheduling, coordinating etc. This method is developed by the construction practitioners for the construction industry. LPS controls all seven channels by establishing

connections, starting discussions, and getting pledges to take action at the appropriate level and moment. The seven channels includes peoples, equipment, information, materials, past work, safe spaces and safe working environment.

LPS includes various tasks such as weekly meetings, reporting etc. In every work there should be a Master plan. But LPS divides the works. Work divisions are mainly carried out on weekly basis that are ready to be done. In traditional work methods, change or unavailability of workers, equipment or any sort of thing occurs which results in work delays and huge monetary losses. These problems will not occur in LPS due to proper scheduling. Since LPS is carried out weekly basis, it helps to analyse the whole week's work by the end of that week. If any problem is faced to complete the work, such issues can be discussed with the responsible persons and make corrections faster without affecting future work. (Bamber, Sharp, & Hides, 1999) states that LPS makes work more efficient. Three Principles were only used for LPS at the initial stage, later on, these principles were not eliminated but more numbers were added to these basic three principles (Ballard *et al*, 2009). Several software's had been developed on the basis of LPS such as BIM (Building Information Modelling).

Transformation Flow Value (TFV) can also be integrated using the LPS. The main principle of TFV is to have maximum production by eliminating waste and non-value-added activities. On the basis of the production concept, Transformation refers to changing of certain inputs into outputs which results in efficient results with proper care in work. Flow helps to inspect the whole process to reduce the non-value added materials and to eliminate the wastes in construction. Value helps to do work based on what actually customer in their proposed construction which resulted in better satisfaction of the customer at the end of the work. On the management side, TFV helps to create a model type that makes the work clearer and more understandable.

4. OBJECTIVES OF THE STUDY

1. To review and classify the literature related to Lean Principles and their application in construction sector.
2. To identify the imperatives that bounds the application of Lean in construction sector.
3. To develop a conceptual framework of assessment of processes with regard to Lean Principles.
4. To design & develop a computer-based model of the above conceptual framework.
5. To evaluate the computer-based system in context of Indian construction industry.

5. METHODOLOGY TO BE ADOPTED

1. An extensive literature review of the publications related to Lean construction will be carried out to identify the research gaps for this research work.
2. The questionnaire survey approach is used in the second stage of research followed by a case study.
3. The research will be a combination of both qualitative and quantitative.
4. Software studies which will integrate MCDM (Multi Criteria Decision Making) using appropriate software's.
5. Analysis of the findings and recommendations for the construction industry.

The first stage of the proposed research starts with an extensive literature study to identify research gaps. In second stage, the research is carried out through quantitative method. Data collection is carried out through questionnaire survey on Likert scale among construction professionals in India. Hypothesis shall be formed and examined. Data Analysis will be carried out through Inferential and Differential Statistics using appropriate software. Collected data shall be analysed to interpret the results. Third stage of the research will be carried out through comparison of different buildings i.e., normal buildings and lean buildings. Sample collection will be carried out from construction firms through semi structured interviews i.e., one normal construction company and one from lean construction company. Data analysis will be carried out through appropriate software. Large numbers of problems are faced by the construction

industry. It helps to solve decisions and problems having multiple criteria. Multi Criteria Decision Making can be carried by Analytical Hierarchy Process (AHP) and Fuzzy Logic. Fourth stage of the research focuses on operational research through Multi Criteria Decision Making (MCDM). Fifth stage of the research deals with the development of a prototype software system and assessment of existing building redevelopment possibilities using appropriate software. Interpretation of results and conclusion, further recommendations for the future study will then be made. Fig 3 shows the flow chart of methodology.

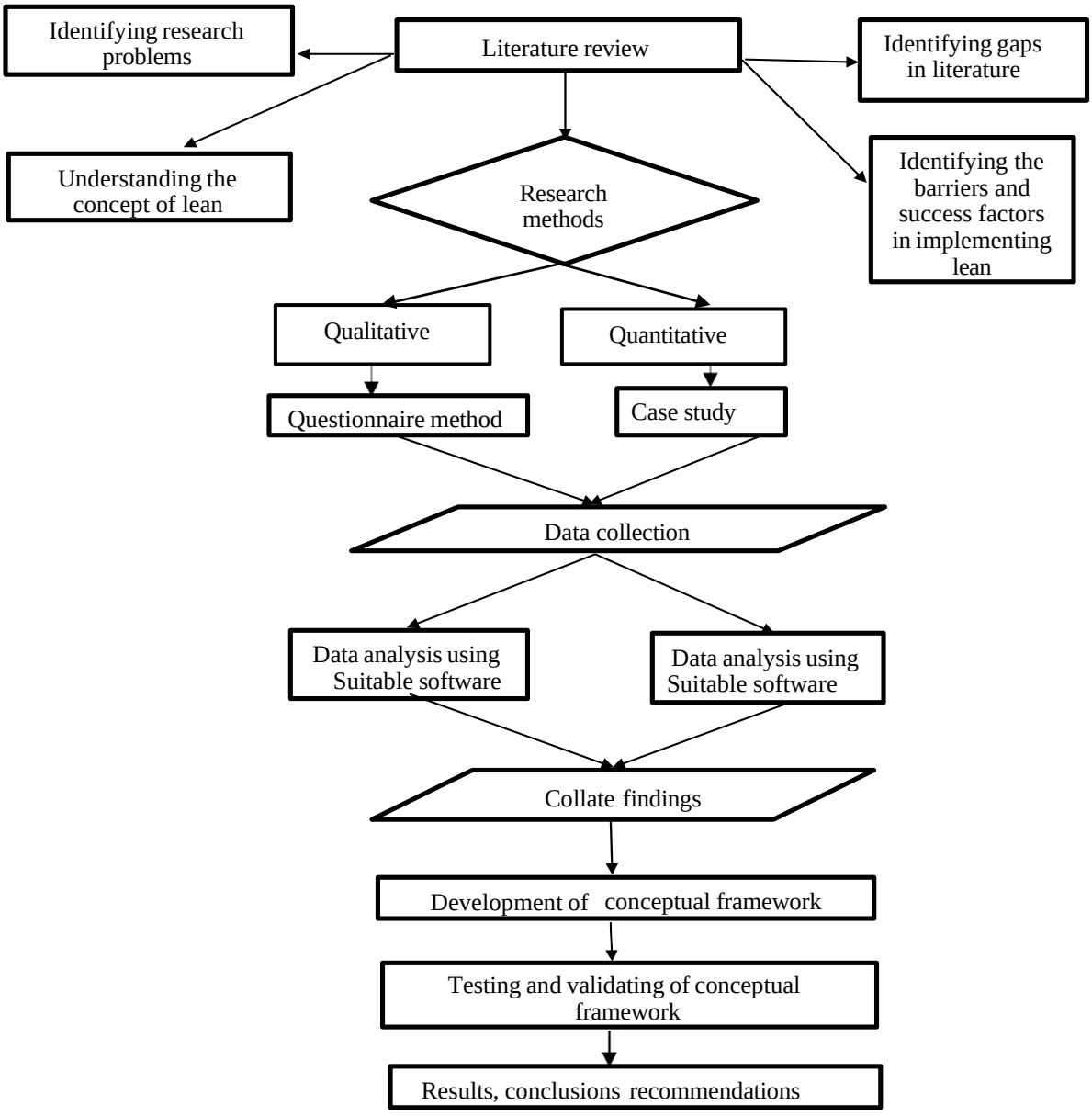

Figure 3. Flow chart of work to be conducted

6. EXPECTED OUTCOME OF THE RESEARCH

The present study will attract the researcher/practitioner to understand what the lean principles are and how they can help the construction sector. In addition, the study will elaborate the lean implementation process in construction management.

An outcome of the proposed lean implementation is

1. Extensive literature review will help to identify the concept of Lean and sustainability. Questionnaire survey will help to identify key barriers and success factors for implementing Lean in the construction industry. The study will depict proper data entry methods which will provide a major contribution to construction industry in managing resources, costs, time etc.
2. Use of appropriate tools of Lean Construction i.e, LPS to deliver efficient projects at the end of construction.
3. The application of implementing Lean can be identified with the help of case study through project management software's for proper resource utilization, optimization, flexibility, waste reduction, cost reduction, better productivity, improved quality.
4. MCDM helps to provide a practical problem-solving structure by using correct methods which resulted in correct judgements multiple solutions to a problem in the construction industries.
5. Building redevelopment possibilities will be investigated with the application of BIM along with MCDM that will help to visualize the redevelopment possibilities as 4D model through BIM.

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